



## Real-time ultrasound guided technique for improving the rapidity of Internal Jugular vein cannulation

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### Abstract

*Internal Jugular Vein is commonly cannulated to obtain central venous access for long term administration of vasopressors, irritant drugs, fluids, haemodynamic monitoring, total parenteral nutrition and haemodialysis in critical care patients. The safe puncture of internal jugular vein can be achieved using anatomical landmarks in the neck. Ultrasound guidance could be beneficial in placing central venous catheters by improving the success rate, reducing the number of needle passes and decreasing the access time. The present study observed the cannulation techniques of internal jugular vein by anatomical landmark and real-time ultrasound guided techniques and compared whether the use of ultrasound improves the rapidity of the cannulation technique. In this study, hundred critical care patients requiring right internal jugular vein cannulation via central approach were allocated to one of the two groups- anatomical landmark guided or real-time ultrasound guided group (50 in each group) based on the technique of cannulation. In our study, there was 86% success rate for first attempt cannulation in the ultrasound guided technique and 68% in the anatomical landmark guided technique. The mean total time of cannulation in the ultrasound guided technique was  $150.68 \pm 16.93$  sec as against  $221.20 \pm 61.91$  sec in the anatomical landmark guided technique. Ultrasound guided technique improves the catheterization technique of the internal jugular vein with respect to rapidity and success rate of the procedure.*

**Keywords:** Central venous cannulation, Internal Jugular Vein, Real-time ultrasound, Anatomical landmark.

### Introduction

Central vein cannulation is a common procedure in medical practice. It plays an important role during resuscitation of patients in critical care as well as emergency room. The central vein cannulation provides a long term and continuous intravenous route for administering drugs and nutrition. It has an important role in disease

management of surgical-oncological patients and hemodialysis patients<sup>1,2</sup>. With advanced knowledge in hemodynamic monitoring, ever increasing value has been placed on the establishment of central venous catheters. During the past forty years, there has been an enormous increase in the use of central venous catheterization and cannulation devices for

various indications and has become an important aid in the management of critically ill patients<sup>3</sup>.

Vascular cannulation is the cornerstone of monitoring and therapy for most serious illnesses<sup>4</sup>. Cannulation by percutaneous route became the urgent, elective and emergency central venous catheterization approach most preferred by anesthesiologists and many intensivists<sup>5</sup>.

Cannulation of the IJV was first described in 1969. The traditional methods of using anatomic landmarks to guide cannulation of the IJV have yielded various rates of successful access and complications. Moreover, central venous catheterization requires considerable expertise.

Doppler ultrasound was first used to assist central venous catheter insertion in 1984. Ultrasound has been applied to describe the anatomy of the IJV and to evaluate various techniques for percutaneous cannulation. Real time sonography improves access to the vein compared with the traditional method and thereby decreases the cannulation time. However, this facility may not be available in many centers because of its high cost. It also needs an experienced operator which is an additional limiting factor for its use.

Real time ultrasonography can be used to view the in vivo vascular anatomy of the neck and in ascertaining the size of IJV and its anatomical relations. It is a useful tool to study the variations in the size of IJV according to various body positions; in finding out the maneuvers which maximize the IJV diameter and in localizing the site of percutaneous puncture. It thereby helps in increasing the first pass success rate and the quality of technique with added safety and rapidity.

Hence, this prospective observational study was an attempt to compare the real-time ultrasound guided technique and the classical anatomical landmark technique of right IJV cannulation (central approach) in terms of number of skin punctures, success rate and total time taken for cannulation.

## Materials and Methods

Hundred patients, above 18 years of age of either sex, admitted in the Critical Care Unit requiring central venous cannulation for various reasons and who gave their informed written consent, were the source of data after obtaining the Institutional Research and Ethical Committee clearances.

Patients with severe bleeding tendencies and coagulopathy states; infections, burns or presence of cancerous lymph nodes in the area; severe respiratory distress, tachypnea, & labored breathing; traumatic injury to neck; restless and uncooperative patients and patients with refusal to take part in the study or retraction of previously given consent were excluded from the study.

A prospective, observational study was used. Prior sample size calculation was done and the sample size was fixed as 50 per group. The group of patients in whom real-time ultrasound guided technique was used was termed the ultrasound guided group (USG group) whereas the other group, in which anatomical landmark technique was used, was called the anatomical landmark guided group (LMG group). The above two groups were observed for their right IJV cannulation techniques (central approach).

In the CCU, both real-time ultrasound guided and anatomical landmark guided techniques are followed routinely for IJV catheterization as per the discretion and expertise of the consultant intensivist and the availability of the ultrasound machine. All consecutive patients eligible for the study as per inclusion and exclusion criteria and requiring right IJV cannulation (central approach) were observed and enrolled into either the 'USG group' or the 'LMG group' based on the technique of cannulation till required sample size of 50 per group was achieved.

After obtaining detailed clinical history, physical examination and written informed consent of the patient; age, sex, BMI, circumference of neck at the thyroid eminence and distance from suprasternal notch to the mastoid process were noted along with baseline recordings of heart rate, ECG, blood pressure and O<sub>2</sub> saturation. Coagulation profile (platelet count, bleeding time,

clotting time, PT-INR, APTT) as well as routine blood and urine investigations were also noted and recorded. A peripheral IV access, resuscitation equipments and drugs were kept ready before starting the procedure. The Seldinger technique was employed for cannulation.

Patient was kept supine with Trendelenburg tilt (15-20°), head turned slightly towards the left side and stabilized with folded towels. A small pillow rest kept to the left of the patient's head allowed greater relaxation of neck musculature and lessen anxiety. Anatomical landmarks (sternocleidomastoid muscle-SCM, sternal notch, cricoid cartilage, clavicle and carotid artery pulsations) were assessed and marked. Right side of the neck region was prepared with an antiseptic solution. The procedure was carried out under deep sedation and local infiltration with local anesthetic solution.

For the real-time ultrasound guided technique, the ultrasound probe was covered in a sterile sheath and placed over the triangle formed by the two heads of the sternocleidomastoid muscle (SCM) and the vessels were visualized in the transverse section. The needle was then inserted under visualization on the US screen. After successful aspiration of venous blood, a J-shaped guide wire was inserted through the hollow needle, and after single passage of a dilator through the guide wire, the triple lumen central venous catheter was rail-roaded over it. The guide wire was then withdrawn and all ports of the central line were checked for free flow of blood. After suturing, a transparent dressing was applied over the area of insertion.

In the anatomical landmark guided technique, the apex of the triangle formed by the two SCMs was palpated for internal carotid artery (ICA) pulsations. Once palpable, the ICA was pressed slightly medially with fingers of the left hand so that it did not overly the IJV. A finder needle of 22G attached to 5ml syringe containing heparinized saline was advanced through the skin just lateral to the point of ICA pulsations, directed towards the ipsilateral nipple at an angle of 20°-30° to the skin. When venous blood was aspirated

the finder needle was used to guide, the seeker needle, a 18G needle connected to a 5ml syringe. After successful aspiration of blood, rest of the steps were similar to that in ultrasound guided technique.

Following observations were made:

- Number of attempts taken to access the IJV. Success rate: -  $\leq 3$  attempts to access the vein was termed successful access.
- Localization time- the time from the puncture of skin using introducer needle to the aspiration of blood into the syringe attached to the needle (sec).
- Access time- the time from the aspiration of blood into the syringe to successful aspiration of venous blood from one of the ports of the catheter after its placement excluding the suturing time (sec).
- Total time- the time from the puncture of the skin to the successful aspiration of venous blood from one of the ports of the catheter (sec) excluding the suturing time (sec). It is the sum of Localization time and Access time.

Data was then analyzed using Statistical Package for the Social Science software trial version 18 and Microsoft Excel. All the quantitative data were analyzed by computing percentages and descriptive statistics viz., mean, standard deviation, and standard error of mean and qualitative data by means of proportions. Quantitative data between the two groups were compared using the Independent sample t-test and qualitative data by means of Chi-square test. Results were considered statistically significant whenever  $p \leq 0.05$ .

### Observation and Analysis

The demographic profile of the patients was comparable with respect to age, sex and BMI in both the groups (Table 1) and the differences were not statistically significant. ( $p > 0.05$ ).

Neck circumference at the level of thyroid cartilage and the distance between right suprasternal notch and the right mastoid process were also recorded in the study. In this study,

mean ± standard deviation of the neck circumference at the level of thyroid cartilage was 36.10 ± 3.20 cm and 35.82 ± 2.27 cm and the distance between right suprasternal notch and the right mastoid process was 16.54 ± 1.62 cm and 16.42 ± 1.61 cm in the LMG group and USG groups respectively as shown in Table 2. p- value obtained was 0.615 and 0.712 respectively and hence not statistically significant.

Among the 100 patients selected for the study, 77 patients were cannulated in the first attempt and 18 in the second attempt. 4 patients required three attempts for cannulation and only a single patient required four skin punctures for catheterization. Using LMG technique 34(68%) cases were cannulated in first attempt, followed by 11 (22%) cases in second attempt and 4(8%) cases in the third attempt. 1 case (2%) required 4 skin punctures for cannulation. However, in the USG group, 43 (86%) cases were cannulated in the first attempt itself and 7 (14%) cases required 2nd attempt for cannulation. Unlike the LMG group, no cases needed 3rd or 4th attempt (Figure 1). Therefore, USG technique clearly reduces the number of attempts for cannulation. However, the observed variable i.e. cannulation attempts was not statistically significant as per the study [Chi-

square value-6.941, Degree of freedom- 3 and p-value -0.074].

As per the study, the mean ± standard deviation of localization time was 12.62 ± 9.08 sec for the LMG technique and 6.46 ± 2.08 sec for the USG technique. p-value obtained was .000 and hence the result was statistically significant. The mean ± standard deviation of the access time in LMG technique was 208.58 ± 54.76 sec, whereas in USG technique it was 144.22 ± 15.79 sec. The above study shows that USG considerably lowers the time for central venous access. The result obtained was statistically significant (p=.000). The mean ± standard deviation of the total time of cannulation was 221.20 ± 61.91 sec for the LMG group and 150.68 ± 16.93 sec for the USG group respectively (Table 3). It can be noted that the mean time of cannulation was significantly lower in the USG group as compared to the LMG group and was found to be statistically significant [p<0.001].

The difference in duration of cannulation between the two groups was statistically significant. USG guidance clearly reduces the localization, access and total time of central venous catheterization of right sided internal jugular vein.

**Table 1:** Demographic distribution among study groups

Variables	LMG (n=50)	USG (n=50)	p value
Age (years)	50.32 ± 15.61	49.46 ± 16.15	p – 0.787
BMI (kg/m <sup>2</sup> )	23.71 ± 2.68	23.25 ± 3.30	p – 0.452
Sex*	Male 29 (58%) Female 21 (42%)	Male 27 (54%) Female 23 (46%)	p – 0.687

LMG - Landmark guided group; USG – Ultrasound guided group; BMI – body mass index

Data as mean ± standard deviation; student’s t-test

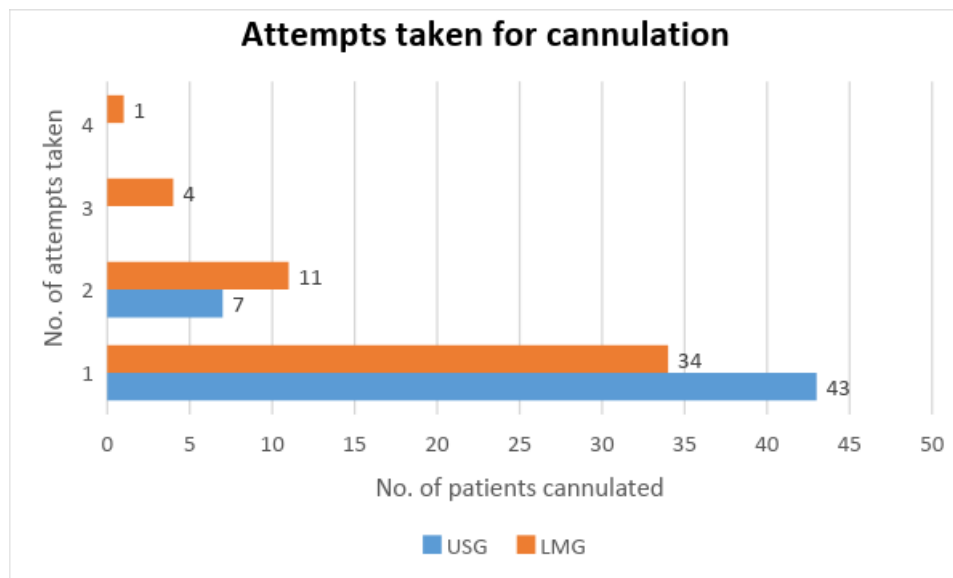
\*Data as number of patients (percentage); Chi square test  
p value <0.05 is considered statistically significant

**Table 2:** Neck dimensions of patients in the study groups

Variables	LMG (n=50)	USG (n=50)	p value
Neck circumference (cm)	36.10 ± 3.20	35.82 ± 2.27	p – 0.615
Distance (cm)	16.54 ± 1.62	16.42 ± 1.62	p – 0.712

LMG - Landmark guided group; USG – Ultrasound guided group; Neck circumference - neck circumference at the level of thyroid cartilage; Distance – distance between right suprasternal notch and the right mastoid process

Data as mean ± standard deviation; student’s t-test  
p value <0.05 is considered statistically significant



**Figure 1:** Bar graph distribution of cannulation attempts among the study groups.  
LMG - Landmark guided group; USG – Ultrasound guided group

**Table 3:** Mean localization, access and total time in the study groups

Variables	LMG (n=50)	USG (n=50)	p value
Localization time (sec)	12.62 ± 9.08	6.46 ± 2.08	p – 0.000
Access time (sec)	208.58 ± 54.76	144.22 ± 15.79	p – 0.000
Total time (sec)	221.20 ± 61.91	150.68 ± 16.93	p – 0.000

LMG - Landmark guided group; USG – Ultrasound guided group; time in seconds

Data as mean ± standard deviation; student's t-test  
p value <0.05 is considered statistically significant

## Discussion

The main objective of this prospective observational study was to find out whether USG guidance reduces the number of skin punctures and improves the rapidity of right sided IJV catheterization. In this study various factors were taken into consideration including various anthropometric measurements, anatomical considerations & qualitative parameters to assess their significance in either of the techniques used. The parameters like age, gender, height, weight or BMI had no significance in this study. The neck circumference at the level of thyroid cartilage and the distance from the suprasternal notch to the right mastoid process was measured to know the girth and shortness or height of the neck and its effect on the study. In the study, in the short and thick neck patients there was difficulty in appreciating the anatomical landmarks and so the number of attempts were more in these cases, especially in the LMG group. There was also

difficulty of insertion with respect to obese patients for the same reason as was appreciated by the study of Defalque et al<sup>6</sup>, and Alderson et al<sup>7</sup>. Using the USG technique, number of IJVs entered in the first attempt were considerably higher as evidenced by 43(86%) vs 34(68%) patients by the USG and LMG techniques respectively. The results obtained in the present study were comparable to the results obtained by the studies of Dimitrios Karakisis et al<sup>8</sup> 100% vs 94.4%, Piero Antonio et al<sup>9</sup> 100% vs 91.6%, Wg Cdr R M Sharma et al<sup>10</sup> 100% vs 98%, Testa A et al<sup>11</sup> 100% vs 82%, Bart G Deny et al<sup>12</sup> 78% vs 43.3%, Mallory et al<sup>5</sup> with 85% vs 15% respectively. A maximum of 4 attempts were made in LMG technique (1.44 ± 0.73) compared with a maximum of only 2 attempts in the USG group (1.14 ± 0.35) with similar results seen with Testa A et al<sup>11</sup> 2.3 ± 1.3 vs 1.2 ± 0.4, Daniel Duque et al<sup>13</sup> 5 vs 2.3 and Hasan Dolu et al<sup>14</sup> 1.1 ± 0.5 vs 2.2 ± 1.6. But the number of attempts made to



cannulate the vein was not statistically significant as per the present study.

The localization time [the time from the puncture of skin using introducer needle to the aspiration of blood into the syringe attached to the needle (sec)] was lower in the USG group than the LMG group. The mean  $\pm$  standard deviation of localization time was  $12.62 \pm 9.08$  sec for the LMG technique and  $6.46 \pm 2.08$  sec for the USG technique with the p-value obtained as 0.000 and hence the result was statistically significant.

The increase in access time [time from the aspiration of blood into the syringe to successful aspiration of venous blood from one of the ports of the catheter] corresponded with an increase in the number of attempts. The access time was shorter in USG technique with a mean of  $144.22 \pm 15.79$  seconds compared to LMG technique having a mean of  $208.58 \pm 54.76$  seconds ( $P < 0.001$ ) comparable with the study of Testa A et al<sup>11</sup>, Hasan Dolu et al<sup>14</sup> and Gurkan Turker et al<sup>15</sup>.

Hence the total time of cannulation [sum of localization time and access time] was considerably lower with the USG technique with a mean of  $150.68 \pm 16.93$  sec as compared to  $221.20 \pm 61.91$  sec for the LMG group and was statistically significant.

### Conclusion

On the basis of our study, we draw the conclusion that ultrasound guidance is beneficial in placing central venous catheters when compared to the traditional land mark guided technique as it reduces the number of skin pricks and improves the success rate. Moreover, there is considerable decrease in the localization, access as well as total time of cannulation of IJV with USG guidance. Also, the sonographic guidance of central venous cannulation is a very good tool for training and teaching the technique to the trainees.

**Source of support:** Self

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